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PATENT SPECIFICATION

1,130,576

NO DRAWINGS.

1,130,576



Date of Application and filing Complete Specification:
15 Oct., 1965. No. 43902/65.

Application made in United States of America (No. 407,900) on
30 Oct., 1964.

Complete Specification Published: 16 Oct., 1968.

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Index at Acceptance:—D1 R3; B2 E(1D, 1H); C3 R(32C8P, 32C11, 32C12, 33C16, 32C25, 32D6C, 32E3, 32E6, 32E10, 32G2, 32J2Y, 32L2X, 32L5D, 32L6H, 32S); D2 B(7, 11B, 14F, 15).

Int. Cl.:—D 04 h 1/00, D 04 h 3/12.

COMPLETE SPECIFICATION.

Sheet Materials and Production Thereof.

We, E. I. DU PONT DE NEMOURS AND COMPANY, a corporation organized and existing under the laws of the State of Delaware, United States of America, of Wilmington, State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improved polymeric sheet materials. It is more particularly directed to such sheet materials which have non-woven base fabrics of entangled, enmeshed, helically micro-crimped fibers, treated with synthetic, organic polymers.

In times past, synthetic polymeric sheet materials, especially those to be used in making shoe uppers and luggage, have been made on woven fabric bases or on non-woven bases prepared by randomly arranging suitable fibers and then needle punching the resulting batts or otherwise treating them to bond the fibers together and give the structures integrity. Sheet materials made on such bases show what is known as "roughening" when they are stressed. This shows up as a peanut-shell effect on the finish of the finished article and so makes the material aesthetically unsuitable for use.

This "roughening" problem has been handled by placing an interlayer fabric between the base fabric and the surface of the sheet material. This, of course, is bothersome and quite expensive. The sheet materials of this invention, however, do not exhibit "roughening" and so the need for interlayers and other devices to obscure it is eliminated. These materials accordingly find their greatest usefulness as shoe upper ma-

terials and as sheets to be used in the manufacture of luggage.

In addition, the sheet materials of the invention are more pliable, show better folding characteristics, have better drape and can be made in a wider range of elasticities than polymeric sheet materials having other woven or non-woven bases. These improvements make the sheet materials of the invention highly suited for the manufacture of gloves, outer garments and accessories such as purses.

THE BASE FABRICS

In preparing the non-woven base fabrics, suitable fibers are processed in such a way that their helical micro-crimps are made to entangle and enmesh with one another to give coherent masses which require no needling, cementing or bonding for their structural integrity.

The fibers, as they occur in the completed base fabrics and in the final products, have from 80 to 1000 helical micro-crimps per inch of unextended length. Micro-crimps, as used here, means crimps which cannot be seen by the unaided eye.

The helical crimp frequency is determined by microscopically counting the number of effective 360° convolutions per inch of fiber. (For example, 2×180° convolutions equal 1×360° convolution.) Base fabrics of fibers having from 100—300 helical micro-crimps per inch are preferred because they give sheet materials with enhanced non-roughening characteristics.

Helically crimped fibers having crimp frequencies somewhat outside this range can be present in the base fabrics, but such fibers give fabrics having reduced coherence, which causes difficulties in processing.

[Pric

"Helical" is used here to described fibers having spiral or corkscrew configurations. The definition, however, is not limited to fibers which describe perfect helices. It also includes fibers whose helices are symmetrical, asymmetrical, regular and irregular, as well as fibers whose helices reverse direction at intervals. In essence, "helical" defines a fiber whose predominant configuration is helical or spiral.

The fibers, as they occur in the base fabric and in the final product, have crimp elongations greater than about 10%. Products preferred for their non-roughening characteristics are made on base fabrics of fibers having crimp elongation values of from 15% to 300%.

Helically crimped fibers having crimp elongation values somewhat outside this range can be present in the base fabrics, but with such fibers the fabrics become progressively stiffer with decreasing values and progressively more elastic with increasing values, to points at which the fabrics give sheet materials unsuited for the uses described.

Crimp elongation values are computed according to the formula

% Crimp elongation =

$$\left(\frac{\text{extended length} - \text{crimped length}}{\text{crimped length}} \right) \times 100$$

Extended length, as the term is used in this formula, means the length of a fiber after it has been pulled straight, but without stretching the fiber itself. Crimped length is the length of a crimped fiber at rest.

These base fabrics have densities ranging from 0.01 to 0.4 grams per cubic centimeter, and have tensile strengths (strip) of 0.05 to about 4.0 pounds/inch/ounce/square yard.

FIBERS USED TO MAKE BASE FABRICS

The fibers used to make the base fabrics must either be manufactured in a way which gives them the proper helical crimp frequencies and crimp elongations to begin with, as defined for the final product, or must be capable of being transformed, during preparation of the base fabrics, into fabrics which have the proper characteristics. The latter type of fiber is said to have helical micro-crimp potential", or to be "helically micro-crimpable".

Fibers having proper crimp frequencies and crimp elongations at the start can be made by mechanically twisting the fibers and then setting the resulting helices with heat.

A number of fibers have helical micro-crimp potential and so are capable of developing suitable crimp frequencies and crimp elongations on exposure to process

conditions in the preparation of the base fabrics. Foremost among these are bi-component fibers composed of two different synthetic polymeric materials, usually in a side-by-side relationship. Helical micro-crimps can be induced in such fibers by subjecting them to some agency which differentially shrinks or relaxes the components. Suitable bi-component fibers are described, for example, in U.S. Patents 2,197,896; 2,287,099 and 2,439,815.

Fibers having helical micro-crimp potential can also be prepared by differential drawing, a process in which one side of a monocomponent fiber is stretched more than the other during its manufacture. Such fibers can also be prepared by jet quenching, a variation of the differential drawing technique. In jet quenching, one side of a monocomponent fiber is cooled more than the other while the fiber is being drawn. By either of the methods, drawing or quenching, fibers are formed which, like the bi-component fibers, can be helically micro-crimped by simply subjecting them to some agency which shrinks or relaxes one side of the fiber more than the other.

Chemically, the fibers can be of any polymer, copolymer, or combination, which can be made into a fiber capable of taking on the proper helical crimp frequency and crimp elongation.

The fibers can, for example, be homofibers or bi-component fibers, in any combination, of polyesters such as poly(ethylene terephthalate), polyamides such as poly(hexamethylene adipamide), acrylics such as polyacrylonitrile, or polyolefins such as polypropylene. Bicomponent fibers of different acrylic polymers or of different polyester polymers are preferred. The homofibers and bi-component fibers can also be of one or more copolymers. Such copolymers as acrylonitrile/sodium styrenesulfonate copolymers, ethylene terephthalate/ethylene isophthalate copolymers, hexamethylene adipamide/hexamethylene sebacamide copolymers, acrylonitrile/vinyl acetate copolymers and acrylonitrile/methyl methacrylate copolymers are suitable.

Bi-component fibers of polyacrylonitrile and an acrylonitrile/sodium styrenesulfonate copolymer are readily available and suitable for use.

Unless the fibers to be used in making the base fabrics have fully developed crimp frequencies and crimp elongation values to begin with, they will have "initial" crimp frequencies and "initial" crimp elongation values which are to be distinguished from these values defining the fibers in the final product. "Initial", in this sense, is used to describe these values in connection with the fibers after their manufacture but before they are processed into base fabrics.

Th initial crimp frequencies of the fibers to be used in making the base fabrics are governed largely by how the fibers are to be handled. If, for example, non-woven batts are to be first made by rando-webbing, helically micro-crimpable fibers having initial crimp frequencies of from 4 to 12 are convenient to use because of the ease with which they can be processed. If carding techniques are to be used in making non-woven batts, fibers having greater initial crimp frequencies can be easily handled.

The helically micro-crimpable fibers should also have initial crimp elongation values of up to 300%. This is important because some of the initial crimp elongation may be lost in subsequent processing, and if one selects initial crimp elongation values which are too low, most of the crimp elongation may be lost, giving base fabrics which are stiff and "boardy".

The length of staple which is to be used in preparing the base fabrics is similarly governed by subsequent treatment. If the fibers are too short, they are difficult to handle; if the fibers are too long, the products are satisfactory but the staple tends to clump in the equipment. Generally, fibers can be used which have an extended length of from $\frac{1}{2}$ " to 3". Shorter fibers can be used, but paper-making techniques must then be employed to form a non-woven base fabric.

The tensile strength and modulus of the fibers to be used can vary within practical limits. It is important only that these properties be such that a satisfactory product will result. Ordinarily, any commercial fiber will be satisfactory from the standpoint of tensile strength and modulus because the criteria which govern whether or not a fiber is acceptable for general commercial use are the same as those which govern acceptability of the fiber for making the sheet materials of the invention. A tensile strength of about 0.5 to 8.0 grams per denier and an initial modulus of about 5 gms./denier to about 120 gms./denier have been found to be satisfactory in most situations.

HOW THE BASE FABRIC IS MADE

The non-woven base fabrics can be prepared according to three basic methods.

In the first method, suitable helically micro-crimpable fibers are subjected to some agency which induces the requisite helical crimp. These fibers, or fibers which are manufactured to give proper final helical crimp frequencies and crimp elongation values, are then carded, rando-webbed, or laid down in random patterns by paper-making techniques. The resulting web is then pressed so that the helices of the fibers entangle and enmesh with those of their neighbors. This gives a finished, coherent base fabric.

In the second method, the so-called "coil-transfer" method, suitable fibers having a proper initial crimp and helical micro-crimp potential are laid down in a loose batt by carding or rando-webbing. This batt is then kept under physical restraint to prevent area shrinkage while it is subjected to an agency which induces helical micro-crimp in the fibers. As the fibers crimp, they entangle and enmesh with one another. When crimping is complete, the restraint is released. The product is a highly coherent non-woven base fabric. Coherence of the product can be enhanced by pressing it after the crimping step.

It has been found that elasticity can be built into the base fabric by allowing a certain amount of area shrinkage instead of keeping the batt under restraint. The amount of shrinkage can be controlled by the temperature of the crimping agency. The elasticity of the base fabric will vary according to the amount of shrinkage permitted, the greater amounts giving the more elastic fabrics. This elasticity can, if desired, be carried over into the final product.

The agency to which the helically micro-crimpable fibers are subjected to induce crimp will naturally vary according to the nature of the fiber. Speaking generally, a helical micro-crimp can be induced in a fiber having helical micro-crimp potential by simply exposing the fiber to heat.

Most bi-component fibers can be helically micro-crimped by exposing them to hot water or to saturated steam, the higher temperatures inducing higher crimp frequencies.

Helical micro-crumps can be effectively induced in bi-component acrylic fibers with dimethylformamide/water mixtures.

Vapors of dimethylformamide/water mixtures having DMF/water weight ratios of from 60/40 to about 20/80 are preferred because of their efficiency, but these mixtures are also satisfactory when used in the hot (50°C. to 130°C.) liquid phase.

In both liquids and vapors, the higher DMF/water ratios favor higher crimp frequencies.

Propylene carbonate and ethylene carbonate-water mixtures can also be used to induce crimp in bi-component acrylic fibers having helical micro-crimp potential.

In the third method, helically micro-crimped continuous filaments are laid down in random patterns by electro-pneumatic spinning techniques more particularly described in British Patent No. 932,482, to form loose batts which are then pressed or calendered to give coherent fabrics. The filaments can be spun as bi-component filaments which are relaxed or shrunk before laydown to develop helical micro-crimp, or they can be homofibers which are knife drawn or jet quenched before laydown.

Contrary to what one might expect, these base fabrics can be needle-punched to give

them added dimensional strength without causing the roughening problem in the final product which ordinarily arises when conventionally prepared base fabrics are needed.

COATING AND IMPREGNATING THE BASE FABRICS

The non-woven base fabrics of helically micro-crimped fibers, prepared as just described, can be used to prepare the sheet materials of the invention by coating or impregnating them with synthetic, organic polymers such as polyvinyl chloride; polybutadiene; polyisoprene; copolymers of vinyl chloride with other ethylenically unsaturated monomers such as vinyl acetate and vinylidene chloride; copolymers of butadiene and acrylonitrile; and copolymers of butadiene and styrene.

Coating can be done by conventional procedures such as calendering, doctor-knife solution coating or by plastisol techniques.

Microporous sheet materials suitable for use as shoe uppers can be made by impregnating non-woven base fabrics, as just described, with polymer systems and methods described in Hollowell U.S. Patent 3,067,482. If shoe upper materials having a high degree of abrasion resistance are desired, the base fabrics impregnated with the materials and according to the techniques disclosed in the Hollowell patent can be top coated with polymer systems and methods disclosed in U.S. Patent 3,100,721 to E. K. Holden.

Any of the polymer systems and methods disclosed in the aforementioned Hollowell and Holden patents can be used to microporously coat and impregnate non-woven base fabrics of helically micro-crimped fibers. The entire disclosures of U.S. Patent 3,607,482 and U.S. Patent 3,100,721 are therefore incorporated into and made a part of this application to show methods and materials for preparing microporous coatings on non-woven substrates.

The polyurethane/polyvinyl chloride polymer system and the techniques described in Example 1 of U.S. Patent 3,100,721 are especially preferred for the quality of the microporous products obtained when they are used.

Shoe upper materials can also be prepared from the non-woven base fabrics by impregnating them with conventional polymers, in amounts small enough so that the resulting structures are still air permeable. These materials can then be micro-porously coated according to the aforementioned Holden method. Illustrative of polymers which can be used to impregnate webs in this way are polyvinyl chloride, polymethyl methacrylate, polybutadiene and polyisoprene.

THE PRODUCT

The product which results from thus treat-

ing a non-woven base fabric of entangled, enmeshed, helically micro-crimped fibers is a uniform sheet material having the following general characteristics:

Density—

between 0.2 and 0.8 gram per cubic centimeter 70

Tensile Strength (Strip)—

within the range of 0.3 lb./in./oz./yd.² to 5.0 lb./in./oz./yd.²

Elongation at break—

between 15 and 400%
(20—150% preferred for shoe upper material) 75

Fisher Pliability Value¹—

between 0 and 1200
(50—900 preferred for shoe upper material) 80

Polymer/Fiber ratio (weight)—

between $\frac{20}{100}$ and $\frac{300}{100}$

$\frac{50}{100}$ to $\frac{150}{100}$ preferred for shoe upper material 85

Roughness Value²—

less than 4

Permeability Value³ (PV)—

0 to 20,000
(1000 to 10,000 preferred for shoe upper material) 90

The base fabric—Since the physical characteristics of the finished product are determined, at least in part, by the characteristics of the base fabric, those characteristics already given for the base fabric can also be used to partially describe the finished product. To summarize, the product has a non-woven fabric base which is a coherent mass of enmeshed, entangled fibers having from about 80 to about 1000 helical crimps per inch and crimp elongation values greater than 10%.* 95

¹ This is determined on a Fisher Pliability Tester, made by the Fisher Body Division of the General Motors Corporation. The pliability value is determined on this instrument by forming a loop with a 1-inch by 3-inch sample and placing the edges of this loop, with the coated side of the sample out, in one of the slots of the sample platform. The platform must be in the down position, with the distance between the platform and the contact foot 105 110

of the thickness gauge dial set at 1.2 inches. The platform is then lifted by turning the crank. The maximum reading on the dial is reported as the Pliability Value in mils.

² Determined on machine model 1004-50B made by Columbia Vice and Manufacturing Co., Cleveland, Ohio. The roughness value of a microporous material is determined on this machine by clamping a 12 in.² sample tightly between ring clamps, coating side up, and distending the material upward with a planoconvex deformation head to a maximum of 1 inch above the original plane. The head is moved by hydraulic pressure over a period of about 15 seconds. Microporous materials which show enough roughening to be unacceptable for use as shoe uppers are rated at 4. Materials which exhibit no roughening are rated 0. Those materials which exhibit roughening between these limits are rated 1, 2 or 3 according to standard photographs; these materials show some insignificant roughening, but are still acceptable. From a practical standpoint, microporous sheet materials having roughness values of less than 4 are called "non-roughening".

^{*} Determined by the test described by Kanagy and Vickers in the Journal of the Leather Chemists Association, 45, 211-242 (April 19, 1950) and in Journal of Research of the United States National Bureau of Standards, April 1950, pages 347-362.

^{*} It may sometimes be difficult, because of their enmeshment to measure the crimp elongation values of fibers after they have been formed into a base fabric. In such cases, a sample of tow is simultaneously run through the coil-transfer process under exactly the same conditions as the rando-web or carded batt. The crimp elongation values of the fibers in the processed tow are assumed to be the same as those in the coil-transferred base fabric.

EXAMPLES

The following examples are presented to describe the invention in greater detail. They are illustrative and are intended to show only the preferred embodiments of the invention.

EXAMPLE 1

Part (A) 1½ inch staple, 1.7 denier (turbo-drawn 2.67× before cutting) of a 45/55 bi-component fiber of polyacrylonitrile and a 96/4 acrylonitrile/sodium styrenesulfonate copolymer is rando-webbed into a batt weighing about 5 oz./yd.².

This batt is then placed between two wooden frames covered with taut cotton sheeting. The frames are clamped tightly together so that they exert a pressure of about 0.02 psi on the batt and the unit is then exposed to the vapors of a 27/73 DMF/H₂O mixture at 108°C. for 5 minutes. This converts the fibers, which had initial helical crimp frequencies of 10 per inch and initial crimp elongation values of 70%, to fibers which have helical crimp frequencies of 150-200 per inch and crimp elongation values of 25-40%. There is no area shrinkage of the batt, although the thickness is reduced to ¼ inch from an original 3 inches.

This batt is then pressed between platens at 200°F., using shims, for 3 minutes, to enhance its coherence and to reduce it to a final density of 0.19 gram/cc.

Part (B) About 3343 parts of polytetramethylene-ether glycol, having a molecular weight of about 1000 are mixed with 291 parts of tolylene-2,4-diisocyanate and heated for 3 hours at about 90°C. About 2485 parts of the resulting dimer are then mixed with 570 parts of methylene bis(4-phenyl isocyanate) and heated for 1 hour at about 80°C. to form a prepolymer with isocyanate end groups.

This prepolymer is dissolved in about 10,000 parts of DMF. The resulting solution is added slowly to a solution of 50 parts of N-methyl-amino-bis-propylamine and hydrazine hydrate, in a molar ratio of 40:60, dissolved in about 1710 parts of DMF.

The resulting reaction mixture is heated at 40°C. for about 30 minutes to form a 20% polyurea solution having a viscosity of about 115 poises. This polyurea solution is then mixed with a 12% DMF solution of polyvinyl chloride homopolymer ("Marvinol" VR 10-U.S. Rubber Co.; "Marvinol" is a trade mark) and DMF. This polymeric solution has the following composition:

Polyurea	8.51 parts
Polyvinyl chloride	4.58 parts
DMF	86.91 parts

A 20/80 water/DMF solution is added slowly to 60 parts of the polymer solution just described until just before the solution becomes opalescent. 11.4 parts of the water/DMF solution are required at which point the solution contains 3.2% water and 11.0 polymer.

The non-woven base fabric made in (A) above is floated on this dispersion at 75°F., until it is saturated. The impregnated base fabric is then pulled over a scraper knife to remove excess liquid.

The dispersion is then uniformly coagulated throughout the base fabric by immersing the impregnated fabric in water at about 75°F. until the polyurethane is coagulated.

The sheet material is then leached with water until it is substantially free of solvent, is oven dried at 275°F., and is then consolidated to a density of 0.45 grams/cubic centimeter by pressing it between platens at 300°F.

Part (C) A solution is prepared as described in part (B), except that the polyurea solution obtained is mixed with the 12% polyvinyl chloride solution in proportions which give a polymeric solution having the following composition:

Polyurea	10.5 parts
Polyvinyl chloride	5.7 parts
DMF	83.8 parts

A 20/80 water/DMF solution is added slowly to 60 parts of this polymer solution until it becomes opalescent. At this point the polymer particles are colloidal and dispersed. 12.2 parts of the water/DMF solution are required to reach this end point, at which the dispersion contains 3.4% water and 13.3% polymer.

A film of this dispersion is knife coated (75 mil clearance) onto the impregnated material prepared in (B). The film is coagulated by immersing the coated material in water, film down. This is then leached in water to remove the DMF, dyed with 2% Nigrosine dye at 212°F. and dried at 220°F. The material is finished with two spray coats of a tannery leather base finish¹ and two spray coats of nitro-cellulose top lacquer². Each coating is oven dried at 200°F. after spraying and weighs about 0.1 oz./yd.².

The material is then grained by pressing it against a smooth grained plate at 6 psi, 300°F., for 3 minutes. The resulting microporous polyurethane sheet material has the following characteristics:

Thickness	35 mils
Tensile Strength (Strip)	2.5 lbs./in./oz./yd. ²
Density	.57 gm./cm. ³
Elongation at break	70%
Roughness value	1
Fisher pliability value	100
PV	2800

This material is excellent for use as an upper material for women's shoes. It shows no roughening when lasted.

¹ No. 7 Pigment (B.B. Chemical Co.)

64 grams

No. 29 Binder (B.B. Chemical Co.)

20 grams

Nigrosine dye solution (2 g. dye/98 g. H₂O) 44 grams

² B.B. Chemical Co. No. 10

EXAMPLE 2

A poly(ethylene isophthalate)/poly(ethyl-

ene terephthalate) bi-component fiber, 1½ denier, having 15 stuffer-box crimps per inch and a crimp elongation value of 10% is cut into 1½ inch staple and then carded into a web weighing 3 oz./yd.².

The web is placed in water heated with steam at 250 lbs./in.² and held there until the water temperature reaches 281°F. Under these conditions, the web shrinks to about 80% of its initial area. The fibers in the resulting web have helical crimp frequencies of about 500 and crimp elongation values of 200—300%.

This base fabric is then split on a leather splitter to give several sheets about 20 mils thick, and is then processed as in Part (C) of Example 1. The resulting somewhat elastic material is highly suited for making gloves. It has the following characteristics:

Thickness	29 mils
Tensile Strength (Strip)	2 lbs./in./oz./yd. ²
Density	.45 gm./cm. ³
Elongation at break	200%
Fisher pliability value	50
Roughness value	1
PV	4000

EXAMPLE 3

Fibers of poly(hexamethylene adipamide), 2 denier, having about 300—500 helical crimps per inch made by twisting and heat setting, and crimp elongation values of 20%, are cut into staple about 1½ inches long and then carded into a batt weighing about 4 oz./yd.². This batt is compressed to about 27 mils thickness for 1 minute at 300°F. to give a coherent mass.

The batt is then processed as in Parts (B) and (C) of Example 1 to give a leather-like material suited for use as a non-roughening upper material for women's shoes. The material has the following characteristics:

Thickness	37 mils
Tensile Strength (Strip)	2.9 lbs./in./oz./yd. ²
Density	.52 gm./cm. ³
Elongation at break	100%
Roughness value	1
Fisher pliability value	232
PV	3300

Similar homofibers and bi-component fibers, fully helically micro-crimped by subjecting them to a suitable crimping agency, can also be processed in this manner to give a similar product.

EXAMPLE 4

A sheet material is prepared according to the procedures disclosed in Parts (A) and (B) of Example 1, except that the base fabric weighs 8.8 oz./yd.². This material is finished with three 0.2 mil spray coats each of the tannery leather base finish and nitrocellulose

top lacquer used in Part (C) of Example 1.

- After these coatings have been oven dried at 200°F., the sheet material is embossed with a smooth grain plate at 300°F. and 25 psi pressure for 3 minutes to give a product suited for use as a non-roughening upper material for women's shoes. The material has the following characteristics:

Thickness	31 mils
10 Tensile Strength (Strip)	3.2 lbs./in./oz./yd. ²
Density	.62 gm./cm. ³
Elongation at break	45%
Roughness value	2
Fisher pliability value	800
15 PV	2300

EXAMPLE 5

- A sheet material is prepared according to the procedures disclosed in Example 4, except for the tannery finishing and embossing steps.

- This material is then roller coated with a 7% solution of "Estane" 5740-X-2* in tetrahydrofuran and oven dried to give a 1½ oz./yd.² coating. The surface is embossed as in Example 4 to give a patent leather surface finish.

- The properties of this sheet material are essentially the same as those shown for the material in Example 4 except for the Permeability Value, which is 0. The material shows no roughening when lasted in the shoe making operation.

EXAMPLE 6

- A non-woven base fabric is prepared according to the procedures disclosed in Part (A) of Example 1. This base fabric is immersed in a 12% solids solution of "Rhoplex" HA8 acrylic latex**. After the base fabric has been thoroughly impregnated with the latex solution, it is oven dried at 300°C.

- This impregnated material is consolidated to a density of 0.45 gram/cc. and microporously coated as in Part (C) of Example 1.

- The resulting microporous sheet material has characteristics substantially identical to the characteristics of the material prepared in Example 1. It is suited for use as a non-roughening upper material for women's shoes.

- *Made and sold by B. F. Goodrich Co.

- **Made and sold by Rohm and Haas Co.

EXAMPLE 7

- A 10 oz./yd.² polypropylene web, prepared according to the methods shown in British Patent 932,482, and composed of continuous filaments having 90—190 helical crimps per inch developed by knife drawing the filaments and allowing them to relax before they are randomly laid down in a

web, is pressed at 200°F. for 3 minutes to a thickness of 75 mils.

This web is then processed as in Parts (B) and (C) of Example 1. The resulting material is useful for upper material in men's shoes.

It has the following characteristics:

Thickness	60 mils
Tensile Strength (Strip)	3.0 lbs./in./oz./yd. ²
Density	.53 g./cc.
Elongation at break	100%
Roughness value	2
Fisher pliability value	700
PV	4500

WHAT WE CLAIM IS:—

1. A non-roughening sheet material comprising a non-woven fabric base treated with a synthetic organic polymer, said base comprising a coherent mass of enmeshed, entangled, helically micro-crimped fibers, said fibers having from 80 to 1000 crimps per inch of unextended length and crimp elongation values greater than 10%, said base having a density of from 0.01 to 0.4 gms./cc. and a tensile strength (strip) of from 0.05 to 4.0 pounds/inch/ounce/yd.², and said sheet material having a density of from 0.2 to 0.8 gram per cubic centimeter, an elongation (at break) of from 15% to 400%, a polymer/fiber ratio of from 20/100 to 300/100, a Fisher pliability value of from 0 to 1200, and a Roughness Value of less than 4.

2. A sheet material according to claim 1 wherein the fabric base comprises bicomponent fibers of different acrylic polymers.

3. A sheet material according to claim 1 wherein the fabric base comprises bicomponent fibers of different polyester polymers.

4. A sheet material according to claim 1 wherein the fabric base comprises bicomponent fibers of poly(ethylene terephthalate) and a poly(ethylene terephthalate)/poly(ethylene isophthalate) copolymer.

5. A sheet material according to claim 1 wherein the fabric base comprises fibers of polypropylene.

6. A sheet material according to claim 1 wherein the fabric base comprises fibers of poly(ethylene terephthalate).

7. A sheet material according to claim 1 wherein the fabric base comprises bicomponent fibers of polyacrylonitrile and an acrylonitrile/sodium styrenesulfonate copolymer.

8. A sheet material according to claim 1 wherein the fabric base comprises fibers of poly(hexamethylene adipamide).

9. A sheet material according to claim 7 wherein the synthetic organic polymer is a polyurethane-polyvinyl chloride blend.

10. A sheet material according to claim 9 having a polyurethane/polyvinyl chloride coating which is microporous and the fibers of the fabric base having from 100 to 300

- micro-crimps per inch and crimp elongation values of from 15% to 300%, said sheet material having an elongation (at break) of from 20% to 150%, a polymer/fiber ratio of from 50/100 to 150/100, a Fisher pliability value of from 50 to 900, and a Permeability Value of from 1000 to 10,000.
11. A sheet material according to claim 7 wherein the synthetic organic polymer is polyvinyl chloride.
12. A sheet material according to any of claims 1 to 11 wherein the fibers are continuous filaments.
13. A sheet material according to any of claims 1 to 12 wherein the non-woven fabric base is made by
- (a) arranging fibers having helical micro-crimp potential into a loose batt, and then
 - (b) subjecting said loose batt to an agency which develops helical micro-crimp in the fibers, while keeping the planar dimensions of said batt constant.
14. A sheet material according to claim 13 in which the fibers in (a) are bicomponent acrylic fibers and wherein the agency in (b) is a dimethylformamide/water mixture.
15. A sheet material according to claim 13 in which the fibers in (a) are 45/55 bicomponent fibers of polyacrylonitrile and an acrylonitrile/sodium styrenesulfonate copolymer and the agency in (b) is the vapor of a 60/40 to 20/80 dimethylformamide/water mixture.
16. A process for the preparation of a non-roughening sheet material according to claim 1, which comprises (a) arranging fibers having helical micro-crimp potential into a loose batt, (b) subjecting said loose batt to an agency which develops helical micro-crimp in the fibers, to form a coherent mass of enmeshed, entangled, helically micro-crimped fibers having the characteristics specified in claim 1 for the fabric base, (c) treating said coherent mass with a synthetic organic polymer until the polymer/fiber ratio is from 20/100 to 300/100, and then (d) drying the treated material to obtain a sheet material having the characteristics specified in claim 1.
17. A process according to claim 16 in which the non-roughening sheet material product is microporous, and wherein the fibers in (a) are 45/55 bicomponent fibers of polyacrylonitrile and an acrylonitrile/sodium styrenesulfonate copolymer, the agency in (b) is the vapor of dimethylformamide/water mixture, and the synthetic organic polymer in (c) is a polyurethane-polyvinyl chloride blend.
18. A sheet material according to any of claims 1 to 12 wherein the non-woven fabric base is made by (a) arranging the helically micro-crimped fibers into a batt, and then (b) pressing said batt to enmesh and entangle the helical crimps in said fibers.
19. A non-roughening sheet material substantially as herein described in any of the Examples.
20. A process for the preparation of a non-roughening sheet material substantially as herein described in any of the Examples.
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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1968.
Published at The Patent Office, 25 Southampton Buildings, London, W.C.2,
from which copies may be obtained.

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